

IEPA – Landfill Gas Management Training Class

Presented by Earth Tech, Inc.





IEPA – Landfill Gas Management

- Introductions
- Goals
- Logistics



IEPA – Landfill Gas Management - Goals

- Learn everything you ever wanted to know about landfill gas
- (In 2 ½ days)



IEPA – Landfill Gas Management

- Introductions

- ◆ Charles

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- ◆ Mike

- LFG Technical Director
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IEPA – Landfill Gas Management

- Logistics
 - ◆ Nap time – 1:30 pm
 - ◆ No homework!
 - ◆ Got Questions?
 - Please ask!
 - ◆ Bonus points if you catch misspelled words!



General Topics

- Day 1
 - ◆ Gas Generation
 - ◆ Regulatory Overview



General Topics

- Day 2
 - ◆ Gas Migration and Surface Emissions
 - ◆ Site Investigations to Assess Landfill Gas
 - ◆ Gas Collection System Design
- Collection System Operation / Monitoring / Reporting



General Topics

- Day 3
 - ◆ Collection System Operation / Monitoring / Reporting
 - ◆ Graduation Ceremony



Let the Fun Begin!

Landfill Gas Generation





Gas Generation

- Landfill Gas – What Is It?
 - ◆ Gaseous by-product of decomposition of organic materials in sanitary landfills under anaerobic conditions



Landfill Gas “Ingredients”

- “Sugar and spice and everything nice”
 - ◆ Not exactly!



LFG Constituents

- Major gases
 - ◆ Methane (CH_4)
 - ◆ Carbon Dioxide (CO_2)
- Trace gases - Hydrogen
- Moisture



Actual Gas Composition

- Methane (CH_4) 45 to 58 %
- Carbon Dioxide (CO_2) 35 to 45 %
- Oxygen (O_2) >1 to 5 %
- Nitrogen (N_2) >1 to 5 %
- Hydrogen (H_2) >1 to 5 %
- Water Vapor (H_2O) >1 to 5 %
- Trace Organics >1 to 3 %



Primary Characteristics

- LFG approx. 50% methane
- Methane is combustible/ explosive gas
- Lower explosive limit (LEL) = 5% CH₄
 - ◆ Lower – not explosive in air
- Upper explosive limit (UEL) = 15% CH₄
 - ◆ >15 %, too rich to be explosive in air



Primary Characteristics

- Heat content
 - ◆ Gas from landfills
 - Approx. 500 Btu/cu ft
- as compared to:
- ◆ Natural gas
 - Almost entirely CH_4
 - 1,000 Btu/cu ft



Gas Generation

- Sources For Constituents
 - ◆ Aerobic Decomposition
 - ◆ Anaerobic Decomposition
 - ◆ Air Leaks
 - ◆ Air Intrusion
 - ◆ Household hazardous waste
 - ◆ Industrial waste



Gas Generation

- Landfill Gas – How is it formed?
- Biochemical Reactions Related To Organic Material Decomposition

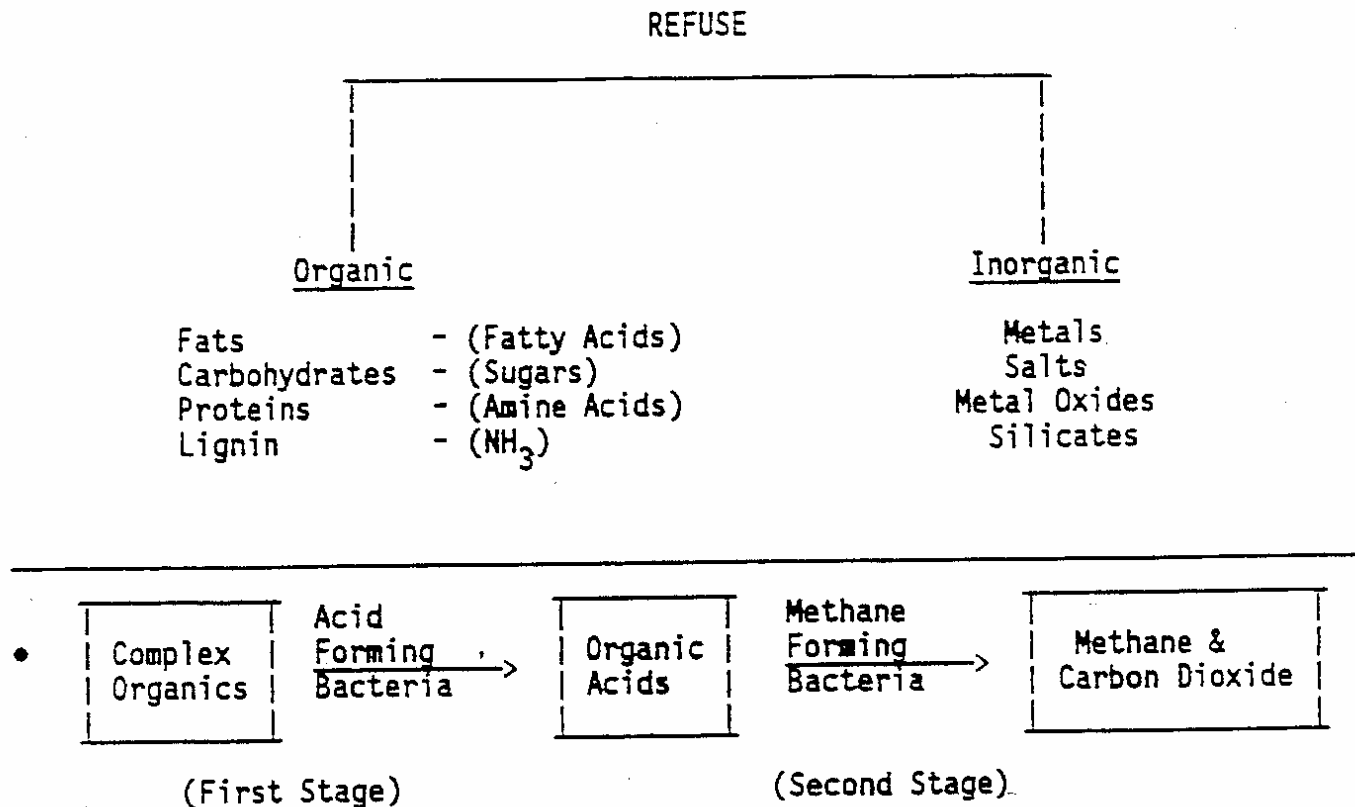


Conditions Required for LFG Generation

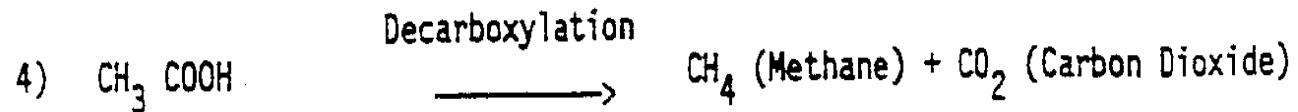
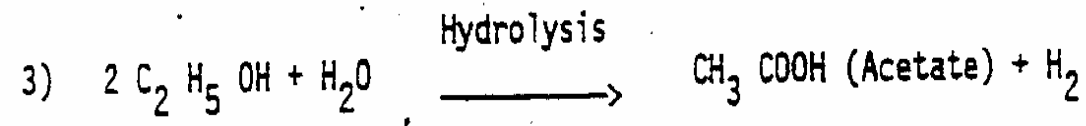
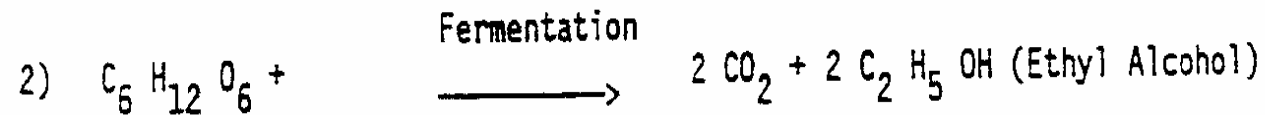
- Organic materials
- Moisture
- Nutrients
- Anaerobic conditions
- Anaerobic bacteria

LANDFILL GAS RECOVERY - CHEMISTRY REVIEW

Anaerobic Decomposition of Organic Waste



Example - Chemical Pathway

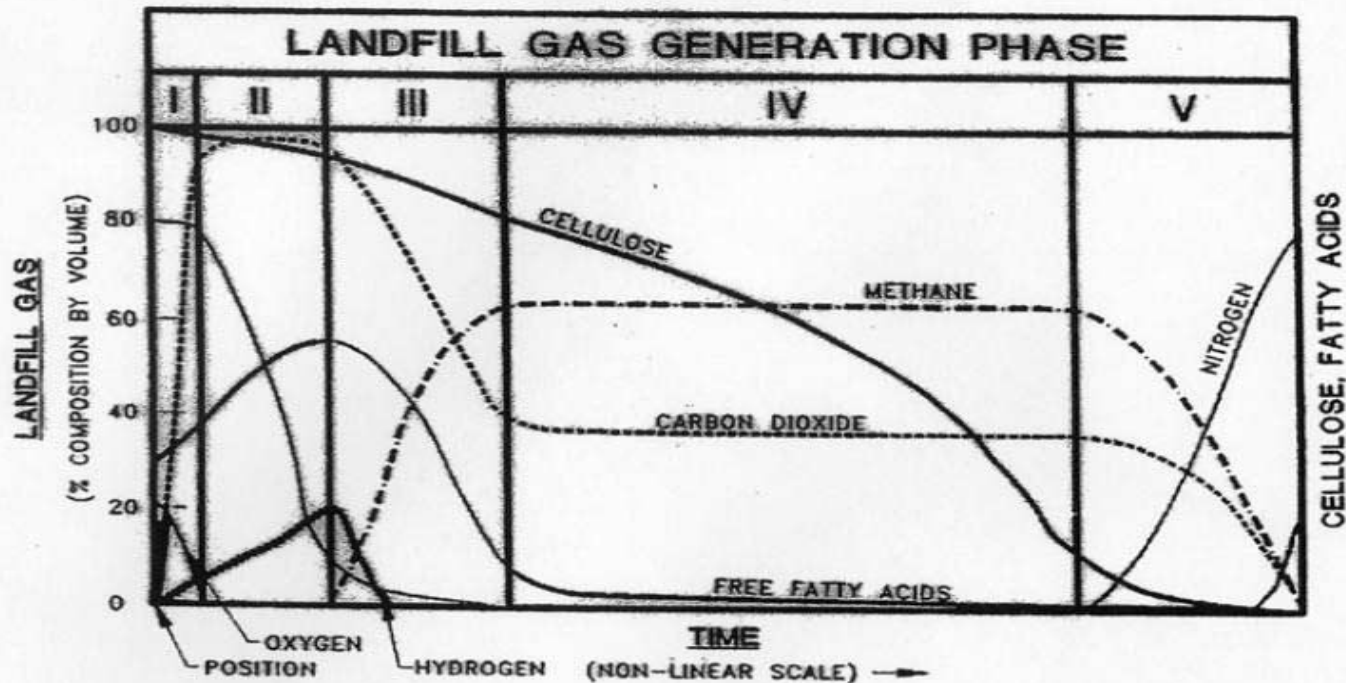




Phases of Decomposition

- Aerobic
- Facultative, acid forming
- Early methanogenic
- Steady methanogenic
- Mature, methane depletion

Phases of Gas Generation



TIME FRAME— TYPICAL USA

- PHASE I — HOURS TO 1 WEEK
- PHASE II — 1 TO 6 MONTHS
- PHASE III — 3 MONTHS TO 3 YEARS
- PHASE IV — 8 TO 40 YEARS
- PHASE V — 1 TO 40+ YEARS
- TOTAL — 10 TO 80+ YEARS

: FARQUAR AND ROVERS, 1973,
AS MODIFIED BY REES, 1980, AND
AUGENSTEIN AND PACEY, 1991



Gas Generation

- Typical duration of phases
- Highly variable
 - ◆ What are the variables?



Factors Influencing Gas Generation

- Refuse quantity
- Refuse composition
- Refuse compaction
- Refuse age
- Moisture content !!!
 - ◆ Liquid addition / bioreactors
 - More on this later



Factors Influencing Gas Generation

- pH and alkalinity
- Nutrients
- Toxics
- Temperature
- Other factors



Factors Influencing Gas Generation

- Air Intrusion
- Methanogens don't like oxygen



Gas Generation

- Implications For Design and Operation



Gas Generation

- Regulatory Implications



Generation Rates

- How much gas does a landfill produce?
- When does it start producing gas?
- How long does it last?

Modeling biological decomposition

- ◆ How much gas will a given volume of trash generate as it decomposes?
 - Methane Yield Potential (Lo)
 - 1.4 to 7.0 cu ft / lb (LFG @50% methane)
 - Average Landfill: 4.5 cu ft / lb (LFG @50% methane)
 - AP-42: 100 cm methane /Mg – 3.2 cu ft/ lb (LFG @50% methane)



LFG Generation Rates

- ◆ How quickly will it be generated?
 - First Order Decay Rate Constant (k)
 - How much gas a given volume of trash will generate per year
 - Range: 0.07 to 0.27 cu ft / lb / yr
 - Average: 0.15 cu ft / lb / yr



Generation Rates

- Controlling Factors
 - Moisture

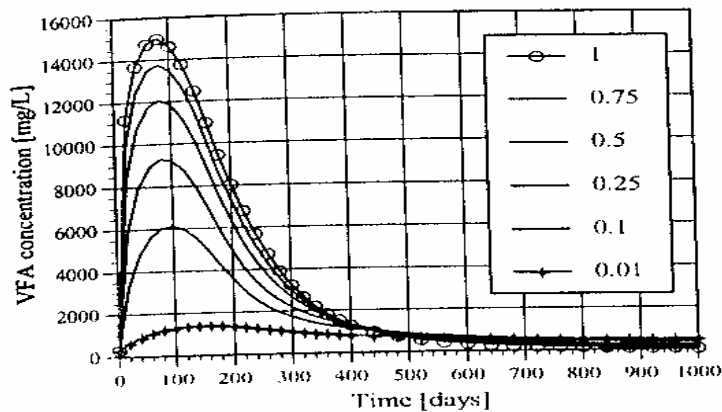


Fig.3a

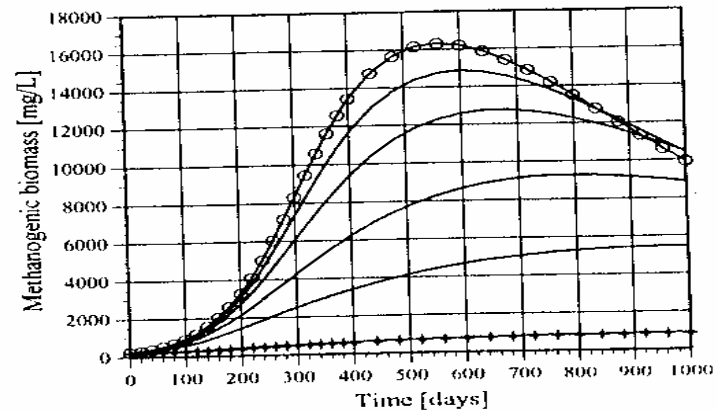


Fig.3b

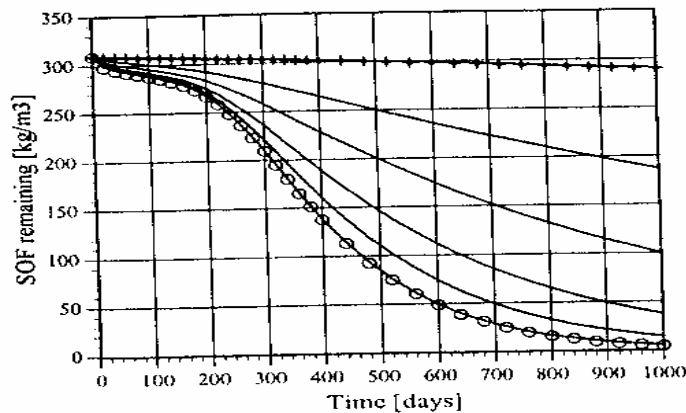


Fig.3c

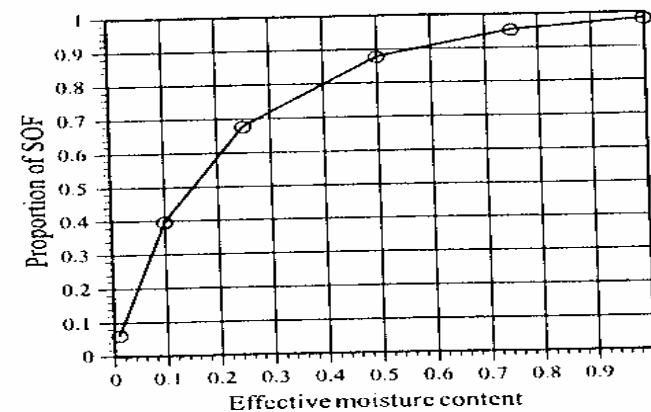


Fig.4

Figure 3. Influence of effective moisture content on biodegradation variables: (a) VFA; (b) MB; (c) SOF.
Figure 4. Proportion of SOF remaining at end of test simulations for various effective moisture contents.

“Moisture Effects in a Biodegradation Model for Waste Refuse”, J.R. McDougall and I.C. Pyrah, Proceedings Sardinia 1999, Seventh International Waste Management and Landfill Symposium.

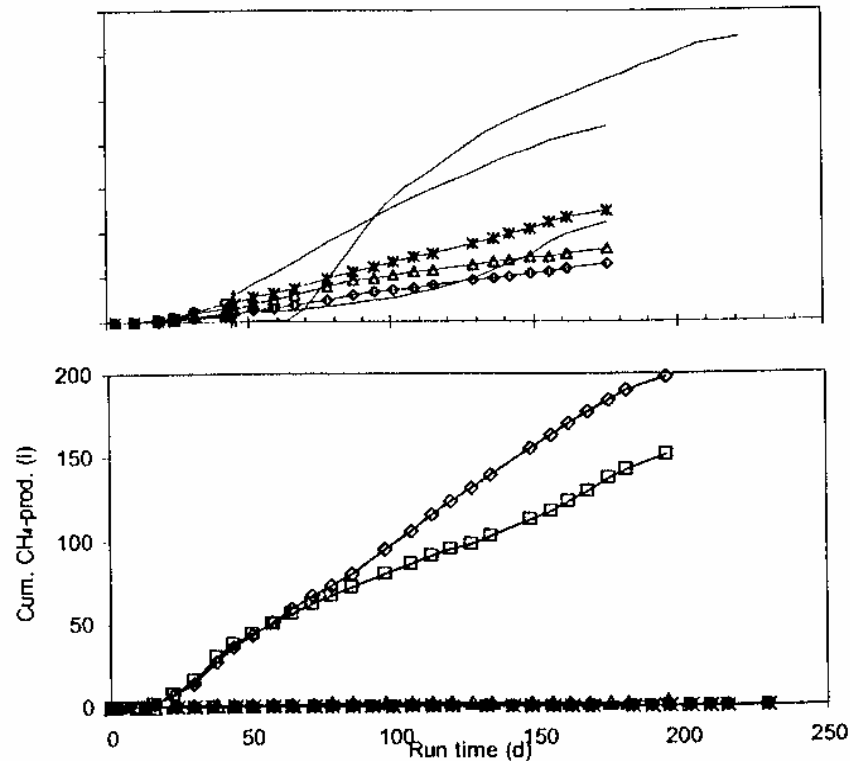


Figure 1. Cumulative methane production during batch experiments (above) with new waste in moisture content of 75% (□) and with old waste in moisture content of 30% (◇), 35% (Δ), 40% (*), 55% (O) and 75% (—) (average of duplicate samples, standard deviation 3-12%) and lysimeter experiments (below) with new waste in L1 (+), L2, (*), L3 (O) and old waste in L4 (◇), L5, (□), L6 (Δ).

“Influence of waste moisture on methane production And leachate characteristics”, J.P.Y. Jokela, R.H. Kettunen, S.K. Martinen and J.A. Rintala, Proceedings Sardinia 99, Seventh International Waste Management and Landfill Symposium.



Generation Rates

- Impact Of Cover Systems
- Geo-synthetic final cover
- Soil final cover
- Old/Abandoned landfills



Generation Rates

- Methods For Control
Re-circulation
Bioreactors



Generation Rates

- Implications For Design and Operation of Gas Systems



Generation Rates

- pH



Generation Rates

- Microbial population



Generation Rates

- Methagens vs. Sulfur Reducing Bacteria



Generation Rates

- Waste Composition



LFG Enhancement

- Elevated moisture content
- Increased moisture throughout
- Sludge addition
- Leachate recycling
- pH adjustment



LFG Enhancement (cont.)

- Nutrient addition
- Organic content
- Temperature adjustment
- Surface treatments

MODELING





Gas Generation Curves

- Why do we need them?
- What are the input values?
- How accurate are they?



Why Do We Need Gas Generation Curves?

- Regulatory drivers
- Gas system design
- Gas system evaluations
- Beneficial use projects



Regulatory Drivers for Gas Generation Curves

- Tier I estimates
- Tier II estimates
- Tier III estimates



Gas System Design

- Estimated gas flow is used to:
 - ◆ Determine number of wells
 - ◆ Size header piping
 - ◆ Size flare and energy recovery facility



Gas Generation Curves - Applications Gas System Evaluations

- Checking the design of the flare to the landfill's expected capacity to generate LFG
- Look at the % of the anticipated LFG that is actually being extracted



Gas Generation Curve - Applications for Beneficial Use Projects

- Used to develop proformas
 - ◆ Evaluates the estimated gas generation over the life of the project
 - ◆ Helps project the payback on capital investments
 - ◆ Helps determine the how many engines / turbines / recovery units are needed year by year over life of project



Gas Generation Curves – Input Values

- LFG generation rate (k)
 - ◆ Cu ft/1b-yr
 - ◆ Calculated by experience and region
- LFG theoretical production (L_o)
 - ◆ Calculated by experience and region
 - ◆ Cu ft/1b



Optimal recoverable LFG

- ◆ Depends on cover types and collection system design
- ◆ Typically 65% - 80%
- ◆ But what happens to the other 20 – 35%?



Gas Generation Curves – Input Values

- Methane Concentration
 - ◆ Use standard 50%
- ◆ Total disposal tonnage
 - Site specific
- ◆ Yearly tonnage
 - Site specific



NMOC concentration

- Site Specific Testing
- USEPA AP-42
- WIAC
- NSPS default
 - As hexane
- ◆ Cover factor
 - Site specific
- ◆ Destruction efficiency
 - 98%



Modeling

- Pluses and minuses of various models
 - ◆ USEPA, Earth Tech, other models



Pluses and Minuses


- Minuses

- ◆ Models do not account fluctuations over time for major variables
- ◆ Models do not account for delayed onset of gas generation

- Pluses

- ◆ Provide design point for gas system
- ◆ Established a basis for energy recovery from landfills

Landfill Gas Generation Model

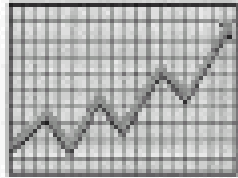
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LANDFILL GAS GENERATION MODEL

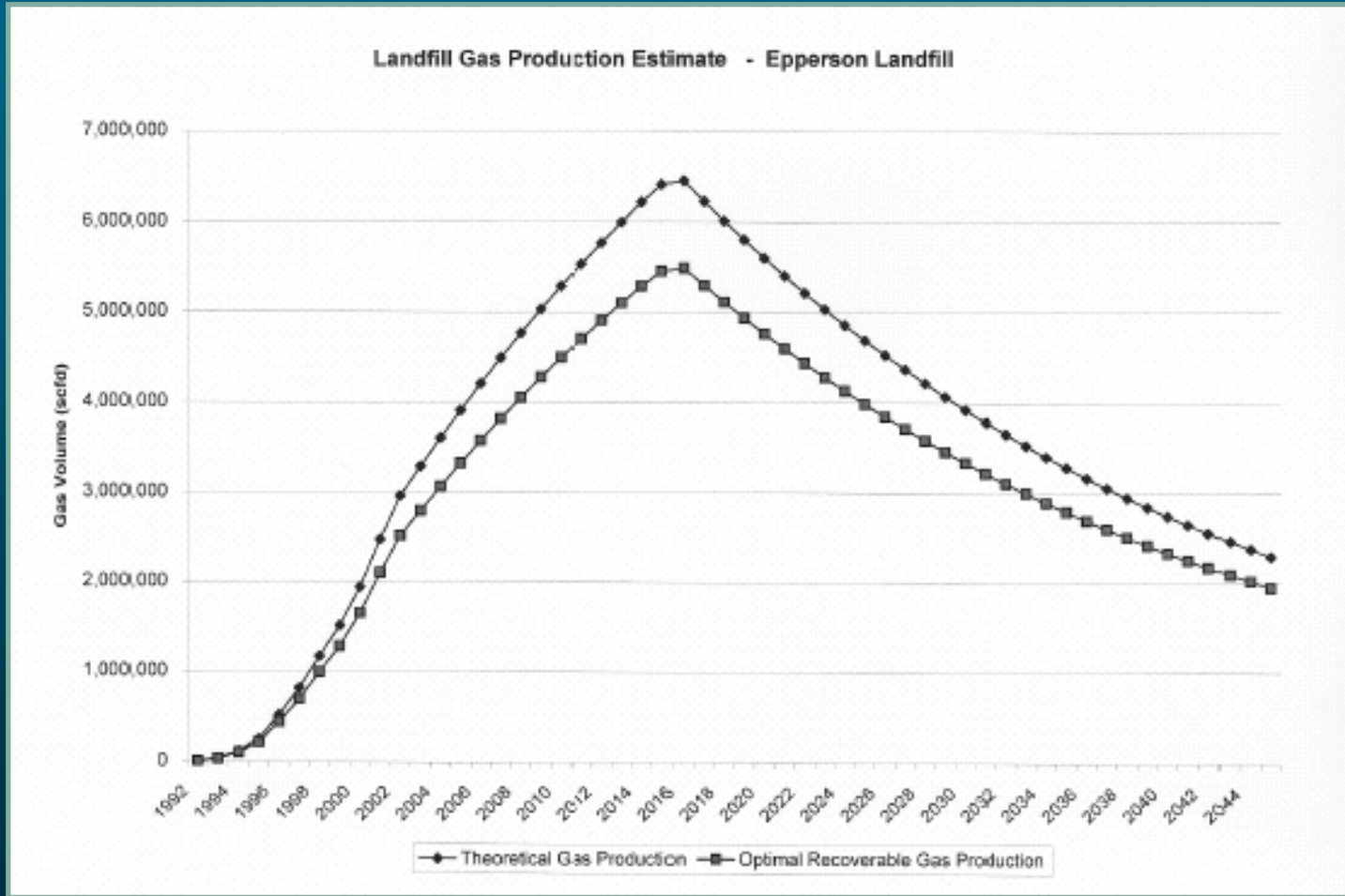
SITE: Epperson Landfill

Options

<input checked="" type="checkbox"/> Standard Gas Volume Curve	<input type="checkbox"/> Engine Usage Curve
<input type="checkbox"/> NMOC Emissions Curve	<input type="checkbox"/> Turbine Usage Curve
<input type="checkbox"/> NMOC / VOC Emissions Curve	<input type="checkbox"/> MSDS Inventory Curve



Landfill Gas Production Estimate





Landfill Gas Production Estimate

- Theoretical Gas Production
 - ◆ (upper curve)
- Vs.
- Recoverable Gas Volume
 - ◆ (lower curve)

Landfill Gas Production Datasheet

4/4/2003

LANDFILL GAS PRODUCTION DATASHEET

excel.krv @person.xls

SITE: Epperson Landfill

LFG Generation Rate: 0.175 CU FT/LB-YR @60°F and 14.7 psia

LFG Theoretical Production: 5 CU FT/LB

Optimal Recoverable LFG: 85 %

Methane Concentration: 54 %

Total Disposal Tonnage: 9,519,959 Tons of refuse

YEAR	ANNUAL REFUSE (tons)	LFG PRODUCED (THEORETICAL) (scfd)	LFG RECOVERABLE (OPTIMAL) (scfd)	LFG PRODUCED (THEORETICAL) Excluding Delay Factor (scfy)	Available Decomposable Waste (lbs)	FUEL (HHV) EQUIVALENT (Recoverable) (mmBTU/hr)	Optimal Recoverable Flow Rate (scfm)	Fueled Engine Usage
1992	24,102	5,778	4,911	8.44E+06	4.85E+07	0	3	0.0
1993	76,757	41,310	35,113	3.50E+07	1.93E+08	1	24	0.1
1994	98,402	118,656	100,857	6.62E+07	3.76E+08	2	70	0.2
1995	286,616	253,956	215,863	1.66E+08	9.16E+08	5	160	0.5
1996	302,489	523,638	445,092	2.66E+08	1.47E+09	10	309	1.1
1997	406,314	820,018	697,015	3.99E+08	2.20E+09	16	484	1.7
1998	373,201	1,172,276	996,436	5.15E+08	2.84E+09	23	692	2.4
1999	487,735	1,511,773	1,285,007	6.61E+08	3.65E+09	29	892	3.0
2000	615,444	1,942,784	1,651,368	8.53E+08	4.71E+09	38	1,147	3.9
2001	650,000	2,473,222	2,102,238	1.05E+09	5.89E+09	48	1,480	5.0
2002	450,000	2,962,002	2,517,701	1.17E+09	6.46E+09	57	1,748	6.0
2003	450,000	3,289,838	2,796,368	1.29E+09	7.10E+09	64	1,942	6.6
2004	450,000	3,606,201	3,065,271	1.40E+09	7.72E+09	70	2,129	7.3
2005	450,000	3,911,491	3,324,767	1.51E+09	8.32E+09	76	2,309	7.9
2006	450,000	4,206,095	3,575,181	1.61E+09	8.90E+09	81	2,483	8.5
2007	450,000	4,490,389	3,816,831	1.71E+09	9.48E+09	87	2,651	9.1
2008	450,000	4,764,732	4,050,022	1.81E+09	9.99E+09	92	2,813	9.6
2009	450,000	5,029,473	4,275,052	1.91E+09	1.05E+10	97	2,969	10.1
2010	450,000	5,284,949	4,492,208	2.00E+09	1.10E+10	102	3,120	10.7
2011	450,000	5,531,482	4,701,760	2.08E+09	1.15E+10	107	3,265	11.2
2012	450,000	5,768,387	4,903,976	2.17E+09	1.20E+10	112	3,408	11.6
2013	450,000	5,998,956	5,098,121	2.25E+09	1.24E+10	116	3,541	12.1
2014	450,000	6,220,909	5,287,432	2.33E+09	1.28E+10	120	3,672	12.5
2015	370,000	6,415,120	5,452,852	2.38E+09	1.31E+10	124	3,787	12.9
2016	0	6,456,686	5,488,182	2.29E+09	1.27E+10	125	3,811	13.0
2017	0	6,230,702	5,296,097	2.21E+09	1.22E+10	121	3,678	12.6
2018	0	6,012,628	5,110,734	2.14E+09	1.18E+10	116	3,549	12.1
2019	0	5,802,186	4,931,856	2.08E+09	1.14E+10	112	3,425	11.7
2020	0	5,598,109	4,758,242	1.99E+09	1.10E+10	108	3,305	11.3

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Landfill Gas Production Datasheet

4/4/2003

LANDFILL GAS PRODUCTION DATASHEET

excelrvr opperson.xls

SITE: Epperson Landfill

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 LFG Theoretical Production: 5 CU FT/LB
 Optimal Recoverable LFG: 88 %
 Methane Concentration: 54 %
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2021	0	5,403,140	4,562,668	1.82E+09	1.08E+10	106	3,169	10.9
2022	0	5,214,030	4,431,826	1.85E+09	1.02E+10	101	3,078	10.5
2023	0	5,031,539	4,276,806	1.79E+09	9.86E+09	97	2,970	10.1
2024	0	4,855,436	4,127,120	1.73E+09	9.51E+09	94	2,866	9.8
2025	0	4,685,495	3,982,671	1.66E+09	9.18E+09	91	2,766	9.4
2026	0	4,521,503	3,843,278	1.61E+09	8.86E+09	88	2,669	9.1
2027	0	4,363,250	3,708,762	1.55E+09	8.55E+09	84	2,578	8.8
2028	0	4,210,537	3,578,958	1.50E+09	8.25E+09	81	2,485	8.5
2029	0	4,063,168	3,453,693	1.44E+09	7.96E+09	79	2,398	8.2
2030	0	3,920,957	3,332,813	1.39E+09	7.68E+09	76	2,314	7.9
2031	0	3,783,723	3,216,166	1.34E+09	7.41E+09	73	2,233	7.6
2032	0	3,651,293	3,103,596	1.30E+09	7.15E+09	71	2,155	7.4
2033	0	3,523,498	2,994,972	1.25E+09	6.90E+09	68	2,080	7.1
2034	0	3,400,175	2,890,146	1.21E+09	6.66E+09	66	2,007	6.9
2035	0	3,281,169	2,788,994	1.17E+09	6.43E+09	64	1,937	6.6
2036	0	3,166,328	2,691,376	1.13E+09	6.20E+09	61	1,869	6.4
2037	0	3,055,907	2,597,181	1.09E+09	5.99E+09	59	1,804	6.2
2038	0	2,948,954	2,506,280	1.05E+09	5.78E+09	57	1,740	5.9
2039	0	2,845,364	2,418,560	1.01E+09	5.58E+09	55	1,680	5.7
2040	0	2,745,777	2,333,610	9.76E+08	5.38E+09	53	1,621	5.5
2041	0	2,649,674	2,252,222	9.42E+08	5.19E+09	51	1,564	5.3
2042	0	2,556,936	2,173,390	9.09E+08	5.01E+09	49	1,509	5.2
2043	0	2,467,443	2,097,321	8.77E+08	4.83E+09	48	1,456	5.0
2044	0	2,381,083	2,023,920	8.46E+08	4.67E+09	46	1,406	4.8
2045	0	2,297,745	1,953,080	8.16E+08	4.50E+09	44	1,356	4.6

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Gas Curve Accuracy

- Only as accurate as the variables used !!
- Very little long term evaluations published to establish accuracy



Gas Curve Accuracy

- SWANA study determined typical models can predict methane production within a factor of 1.5
- However, this was for only 80% of the data, with greater than that for the remaining 20%
- Almost half of the landfills studied were in California



Modeling

- Theoretical Gas Volumes vs. Actual Collected Gas Volumes



Modeling

- Regulatory Implications



Modeling

- Data Limitations
 - ◆ Flow Measurement
 - ◆ Gas Quality Measurement

REGULATORY OVERVIEW





Regulatory Overview

- Landfill NSPS / Emission Guideline (EG)
- Title V Permits
- Source Construction Permits
- New Emission Standards for Hazardous Air Pollutants for Municipal Solid Waste Landfills (NESHAP, MACT)



Clean Air Act Amendments 1990

- New Source Performance Standards
- Title V Operating Permit Program
- NESHAP and MACT Standards



Landfill NSPS / EG

- Only real difference is timing for implementation
- NSPS is applicable for landfills that have been constructed, reconstructed, or modified after May 30, 1991 – rule became enforceable March 12, 1996
- EG is applicable to landfills that accepted MSW after November 8, 1987 or has additional design capacity available – rule became enforceable January 22, 1999



Rule Details

- Landfills with a design capacity of 2.5 million cubic meters or Mg must calculate NMOC emissions
- Emission rate of NMOC ≥ 50 Mg requires gas system
- Emission rate of NMOC < 50 Mg must recalculate annually



Landfill Owner/ Operator Responsibilities

- Design
- Installation
- Monitoring
- Recordkeeping
- Reporting
- Corrective Actions



Monthly Wellfield Monitoring

- All wells, every month
- Three parameters must be obtained at EACH WELL: pressure, N2 or O2, and temperature
- Follow-up actions/timeframes required for non compliant wells
- Cover Integrity Survey
- Documentation of all activities is required



Wellhead Monitoring

- Temperature
- Pressure (gauge pressure in the gas collection header)
- Nitrogen or oxygen content



Wellhead Deviations

- Temperature greater than 131 degrees Fahrenheit
- Positive static pressure
- Oxygen content greater than 5%



Corrective Actions for Wells - Time Table

- If any exceedance occurs, corrective action is to be taken within 5 calendar days of the initial reading.



Corrective Actions for Wells - Time Table (con't.)

- Exceedance must be corrected within 15 calendar days of the initial reading.



Corrective Actions for Wells - Time Table (con't.)

- If the exceedance still exists, the well field must be expanded within 120 days or an alternative timeline/ action plan is to be approved by the administrator.



Surface Monitoring

- Quarterly monitoring required
- Establish a background concentration.
- Keep the probe inlet within 5 to 10 cm of the ground, move in a traverse pattern with a spacing of 30 meters apart.



Surface Monitoring (con't.)

- Any signs of distressed vegetation or erosion outside of the pattern should be monitored.
- Not required to monitor unsafe areas
 -



Surface Monitoring (con't.)

- Mark areas with a concentration of greater than 500 ppm above background. Record concentration.
- If the concentration is greater than 500 ppm, corrective action must be implemented.
- Area must be remonitored within 10 days of the *initial* exceedance.



Surface Monitoring (con't.)

- If still above 500 ppm, area must be remonitored within 10 calendar days of the 2nd exceedance. If location is still greater than 500 ppm, a 120 day corrective action plan must be implemented.
- If after the first 10 day remonitoring the location is less than 500 ppm, the location is to be monitored within 30 days from the *initial* exceedance.



Surface Monitoring (con't.)

- 30 day remonitoring is less than 500 ppm – no further action.
- 30 day remonitoring greater than 500 ppm, a 120 day action plan must be implemented.



Surface Monitoring Report

- Calibration data
- Meteorological conditions (Average temperature, average wind speed, average wind direction, and skies)
- Map of pattern walked
- Location and concentration of any hits and remonitors



Other NSPS Monitoring

- Gas Flow to Control Device
- Utility Flares (Flame Present)
- Enclosed Flares (Temperature)
- Gas Recovery Plants (Temperature or O₂ in Exhaust)



Performance test

- Control device must tested to demonstrate compliance



NESHAP REQUIREMENTS



OVERVIEW

- 40 CFR Part 63, Subpart AAAAA was promulgated on Jan 16, 2003.
- If facility is subject to NSPS/EG and required to install a gas collection and control system, NESHAP will apply.



Requirements of NESHAP

- Requires facilities to operate collection and control system.
- Facilities must prepare, follow, and maintain a startup, shutdown, malfunction (SSM) plan.
- Semi-annual reporting of deviations required.



Collection/Control System

- If the collection system meets the requirements of NSPS/EG, the collection and control system meet NESHAP requirements.



SSM Plan

- Goal of SSM Plan is to minimize downtime and emissions
- Must include:
 - ◆ Procedures for operating and maintaining GCCS during SSM events
 - SOPs, O&M Manuals
 - ◆ Corrective actions for malfunctioning equipment
- SSM Plans on file by 1/16/2004



SSM Plans - Definitions

- Start-up / shutdown:
 - ◆ *setting into/cessation of operation of an affected source or portion of an affected source for any purpose*



SSM Plan Implementation and Compliance Issues - Definitions

- Malfunction: *any sudden, infrequent and not reasonably preventable failure of control, process or monitoring equipment to operate in normal manner which causes/has potential to cause emission limitations to be exceeded.*



SSM Plan Implementation and Compliance Issues - Definitions

- *Poor maintenance/careless operation
not considered a malfunction*



SSM Plans - Record Keeping

- Document each event/confirm SSM Plan was followed
 - ◆ Checklist, log book
- Keep copy of SSM Plan in site file
 - ◆ If revise SSM Plan, keep current plus all old versions for up to 5 years
- Not required to submit SSM Plan, however:
 - ◆ Agency can require revisions



SSM Plan Implementation and Compliance Issues

- Classifying an SSM event
 - ◆ Refer to definitions of SSM
 - ◆ What if the event is not an SSM?
 - ◆ Keep records when in doubt



SSM Plan Implementation and Compliance Issues, (cont'd)

- How detailed should the SSM Plan be?
 - ◆ Must cover individual devices
 - ◆ SOPs should be open/flexible by design
 - ◆ Be clear on what is/is not covered



SSM Plan Implementation and Compliance Issues (con't.)

- Exemptions from the Plan
 - ◆ Control devices operating on treated LFG
 - ◆ Auto flare operations
 - ◆ Well/surface emission exceedances
 - ◆ Portable monitoring equipment



SSM Plan Implementation and Compliance Issues (con't.)

- Third Party Operators
 - ◆ Developers and O&M contractors
 - ◆ Contractual obligations
 - ◆ Constant and consistent communication is key



Immediate Reporting Requirements

- Failure to follow SSM Plan and emission limitation exceeded
 - ◆ Report to agency within 2 days of occurrence
 - ◆ Written report to agency within 7 days of SSM conclusion



Reporting Requirements - Semiannual

- Deviations
 - ◆ “Bad” monitoring data
 - ◆ Combustion temperature deviation for enclosed combustors
 - ◆ No SSM Plan



Periodic Reporting Requirements

Summary of SSM events

- Where followed SSM Plan, then state such in report
- Where deviated from SSM Plan, but no emission exceedance, then identify deviation(s)



Periodic Reporting Requirements

- ◆ Summary of SSM events (cont'd)
 - Where deviated from SSM Plan and emission exceedance, then include number, duration and description of each event.
- ◆ If revised, then identify changes made to the SSM Plan



Periodic Reporting Requirements

- Semi-Annual NSPS Report
 - ◆ 40 CFR60.757(f) data
- Can combine SSM and NSPS reports
 - ◆ First report due July 30, 2004

Gas Migration and Surface Emissions





Why Did The Landfill Gas Cross The Road?

- Because it was the path of least resistance
- Gas is lazy.
- It always follows the path of least resistance.

Mechanisms of Gas Movement

- ◆ Convection (pressure gradients)
- ◆ Diffusion

Surface Emissions and Odors





Surface Emissions and Odors

- Causes
 - ◆ Data Limitations

Regulatory Implications





Corrective Actions

- Well Adjustments
- New Wells
- Other Systems



Offsite Migration

- Typical Migration Pathways
 - ◆ Sand seams
 - ◆ Utilities
 - ◆ Other



Where To Look For Migration

- Techniques To Investigate Migration
 - ◆ Permanent Bore
 - ◆ Bar Punch
 - ◆ Hydraulic Punch


Out-of-Refuse Probe Monitoring





Why Monitor Gas Probes?

- Monitor for lateral (subsurface) LFG migration
 - ◆ Determine if a pattern of LFG migration exists
 - ◆ Determine the extent of any LFG migration
 - ◆ Determine if any explosive gas hazard is present
 - ◆ Evaluate effectiveness of LFG system operation



Why do we have gas probe monitoring?

- Protect the human health and the environment
- Fulfill and document regulatory compliance
 - ◆ Explosive gas monitoring plans
 - ◆ Subtitle D monitoring



Types of Probes

- Temporary barholes
- Permanent installations

Probe Monitoring Procedures

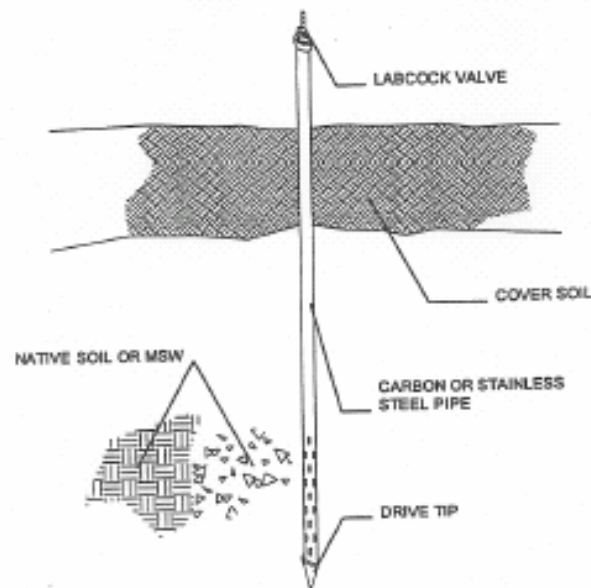


Figure 6.3
Typical Driven Gas Probe

6.3. PROBE MONITORING PROCEDURES

Prior to collection of probe monitoring data, the technician should obtain the following:

- A map showing probe locations and gas well locations
- Information on landfill depth
- As-built monitoring probe details
- As-built control well details
- Hydrologic/geologic reports
- A sample pump and knowledge of sample pump flow rate. Note sample pump may be integral to the monitoring instrument.



Probe Monitoring Procedures

- Record the following:
 - ◆ Name of technician
 - ◆ Date and time
 - ◆ Ambient temperature
 - ◆ Weather conditions
 - ◆ Atmospheric pressure
 - ◆ Probe ID and location
 - ◆ Slot interval depth



Probe Monitoring Procedures

- Record the following:
 - ◆ 1) Probe pressure
 - ◆ 2) Methane %, O₂ %
 - ◆ 3) Liquid level



Probe Monitoring

- Which is more important?
- Initial reading or after meter reaches equilibrium?



Things to Watch Out For

- Liquid levels above the screen interval
 - ◆ High liquids may block screen
- Loss of probe depth
 - ◆ Due to silting
 - ◆ May need probe replaced
- Damage to probe casing
 - ◆ Vandalism



Sources of Gas in Probes

- Naturally Occurring Methane
 - ◆ Coal Bed Methane
 - ◆ Swamp / Wetland
 - ◆ Peat deposit
- Natural Gas Pipelines and other man-made sources
- Landfill



Ways to Distinguish Between Landfill Gas and Other Methane

- Identifying halogenated compounds
 - not typically present in natural sources (especially freons)
- Isotope analysis
- Establish gradient from source

A vertical collage of four images. The top image shows a construction worker in a yellow safety vest and blue jeans standing next to a large black pipe in a grassy field. The second image is a close-up of a cable-stayed bridge structure against a sunset sky. The third image shows a mountain range with snow-capped peaks reflected in a calm lake, with a dense forest in the foreground. The bottom image is a close-up of a large industrial pipe with the text 'LANDFILL GAS' written vertically on it.

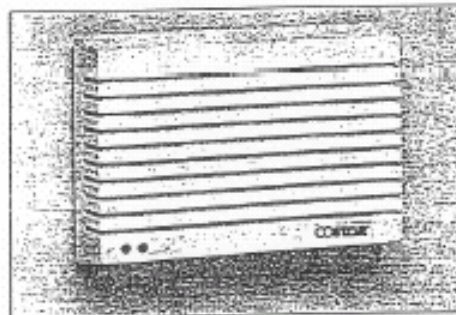


A Tyco International Ltd. Company

Warning of Dangerous Atmospheres

Process: *AC Calorimeter Gas Monitor* detects a wide variety of atmospheric gases, including methane, hydrogen, carbon monoxide, ethylene, ethane, propane, butylene, acetylene, chloroethane, chloroform, ethylene oxide, ethyl ether, from a 13-dipropyl methyl ether, carbon monoxide, hydrogen cyanide, hydrogen chloride, toluene, styrene and more. Factory set point is 100 ppm methane/400 ppm hydrogen. Carbon Monoxide Monitor sounds alarm at 50-100 ppm, squirts red dye at 110-400 ppm. Response time at 100 ppm is 1-2 minutes to reduce the incidence of false alarm due to transient, episodic, slight concentration above and just seconds. *AC Hydrogen Sulfide Monitor* sounds alarm at 50 ppm. Adjusts from 10-90 ppm. Response time 1-2 minutes at 50 ppm to prevent false alarms. 50-90 seconds at 100-250 ppm. *AC Calorimeter Kit* include calorimeter, two calibration gas cylinders, test gas and valves.

Part Number	Description	Quantity	Unit Price	Total Price
WD-3050	Combustible Gas Monitor	1	\$23.00	\$23.00
WD-3050	Carbon Monoxide Monitor	1	\$11.00	\$11.00
WD-3050	Hydrogen Sulfide Monitor	1	\$18.00	\$18.00
WD-3050	Methane Calibration Gas	1	\$12.00	\$12.00
WD-3050	CO Calibration Gas	1	\$12.00	\$12.00
WD-3050	Hydrogen Calibration Gas	1	\$12.00	\$12.00



*Excellent Audible/Visual Warning Alarm for
Furnace Rooms and Garages*

Specifications: Under normal conditions, alarm activates when air has accumulated 50 ppm over approximately eight hours. If concentrations increase sharply to 300 ppm, alarm activates in about 30 minutes. Runs for one year on 9V battery.

No.	Description	Each
WR.17553	Carbon Monoxide Alarm	105.00
WR.17544	Replacement Sensor	20.55



Early warning gas alarm detects both natural gas (methane) and propane gas at concentrations of 25% or less of the Lower Explosive Level (LEL). Sensitivity test switch simulates the presence of gas.

Specifications: 85dB alarm sounds before gas builds up to dangerous level. In case of absence, red light stays on to warn that alarm has been set off. Pre-set alarm needs no adjustments; comes complete with low battery indicator, 120V AC. Temperature range: -10° to 30°C. 354"H x 434"W x 134"D.

WB-7503

A BETTER TOMORROW made possible



Other Types of Explosive Gas Monitoring

- Building monitors
 - ◆ Sierra monitors
 - ◆ Personal detectors
 - MSA / Passport



Identifying The “Problem Area” of the Landfill

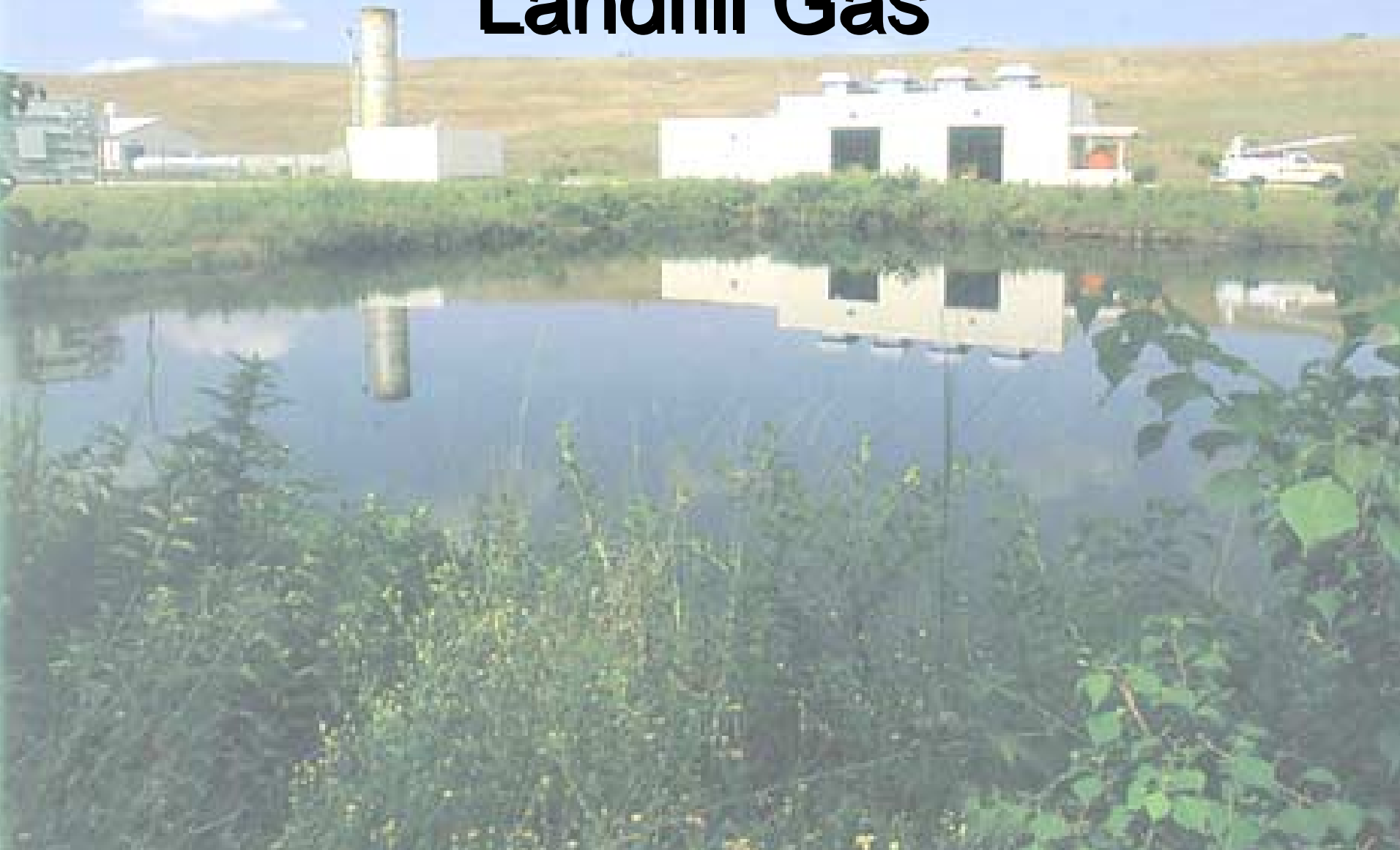
- i.e., the source of the migration
- Migration on the west side of the landfill indicates a problem on the west side, right?
 - ◆ Not necessarily
 - ◆ Geologic factors
 - ◆ Sand seams beneath landfill
 - ◆ Gradients



Fixing the Migration

- Assess the risk
- Modified Tuning Strategy
- New Extraction Wells
- Cut-off systems

Site Investigations to Assess Landfill Gas





Site Investigations to Assess Landfill Gas

- Methods
- Data Interpretation
- Venting and Collection System Decisions



What to do?

- Abandoned landfill
- No base liner or leachate collection
- No records regarding:
 - ◆ Waste depth
 - ◆ Waste type (C&D, MSW, etc.)
 - ◆ Site geology
- General idea of waste age

What to do?

- Subdivisions have sprouted on two sides of the landfill
 - ◆ With basements

How to Assess the Risk



The Plan



Estimate the Current Gas Generation





Check the Geology

- Look for pathways



Field Methods to Check for Gas Migration

- Borings
- Geoprobes
- VSI's
- Barhole probes
- At property line and off-site?



Field Data to Collect

- Geologic info
- Gas constituents
- Gas pressures



Getting the Most Bang for Your Buck

- (figuratively, not literally)
- Geoprobes and VSI's
- Get good data!



Data Interpretation – What's It All Mean?

- Interpreting methane concentrations
- Interpreting pressure
- Identifying pathways
- Assessing risk to human health and the environment



Making Some Decisions

- What's Needed to Protect Human Health and the Environment?
- What's most cost effective?
- Active System?
- Passive System?
- Barrier System?
- Basement monitors?
- Nothing?



Passive System

- System that relies on pressure or concentration gradients to function
 - ◆ Vertical vents, gravel trenches



Active System

- System that includes a prime mover that creates a vacuum on the landfill
 - ◆ Vertical gas wells
 - ◆ Horizontal collectors



Barrier System

- Slurry wall
- Engineered Barrier
 - ◆ Geosynthetics vibrated into a trench

Basement Monitors





Pluses and Minuses

Measure	Pluses	Minuses
Passive	Low cost	Small zone of influence
Active	More effective than passive	Higher capital cost and operating cost
Barrier	Effective, IF barrier is complete	High Cost Requires more geologic investigation
Basement Monitors	Monitoring at the site of the risk. Low cost	Higher risk. Politically unpopular
Nothing	Lowest cost	Higher risk.



Summary

- Not every site needs active gas collection
- Do some investigation, assess the risk
- Implement in phases?
 - ◆ Start with probes or building monitors
 - ◆ Add additional measures based on results